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Torque and Rotational Motion (11th grade)

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Understanding by Design

Unit Cover Page

Unit Title: Torque and Rotational Motion
Grade Level: 11^{th}
Subject/Topic Area(s): AP Physics 1
Designed By: Connor Gorman and Leslie Salazar
Time Frame: 4-5 weeks
School District: NEISD
School: Johnson HS
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Brief Summary of Unit:

The creation of the new AP Physics 1 course has introduced quite a few changes into the curriculum which have proven challenging for students. In particular, AP Physics 1 requires that students possess a deep, working knowledge of algebraic processes along with a sharp understanding of physics concepts which can be utilized in tandem to solve a wide array of problems given from many different perspectives. Within the angular dynamics unit, students must incorporate what has proven to be an incredibly difficult series of physics concepts into this repertoire. This unit was written to help with the process students must go through in order to incorporate these concepts into their physics vocabulary by providing a meaningful goal along with opportunities after each set of material to connect their learning to past and present technologies.

The unit's main goal is to prepare students to work collaboratively on a project team to design, build, test, and assess a catapult or trebuchet. Students are provided the opportunity to solidify their understanding of particular components of angular dynamics through various forms of assessment including quizzes and labs.

Note: For most up-to-date access to files, please visit this link for the Google Drive folder.

UbD Template 2.0

<table>
<tr><th colspan="3">Stage 1 – Desired Results</th></tr>
<tr><td rowspan="6">Established Goals (e.g., standards)

• See “Big Ideas” attachment</td><th colspan="2">Transfer</th></tr>
<tr><td colspan="2">Students will independently use their learning to…
• Work collaboratively with other individuals on a project team to plan, construct, test, and assess a solution to a proposed problem. This will be accomplished through the following project:

Design and build a catapult or trebuchet for precision and range and justify design decisions from a physics based perspective (specifically including knowledge of torque and rotational motion/momentum). Students will also to test, analyze, and assess said design and suggest improvements citing specific physics based reasons.</td></tr>
<tr><th colspan="2">Meaning</th></tr>
<tr><td>Understandings
Students will understand that…
• Concepts in torque and rotational motion are historically and currently utilized in technological design.
• The understanding of concepts in physics is constantly evolving within the scientific community and within individuals (students will now have to consider rotational dynamics in addition to linear dynamics).
• Past/present technologies can be improved upon using current/future physics understandings and techniques.</td><td>Essential Questions
• What are the practical applications of studying, understanding, and analyzing rotational motion?
• What additional considerations have to be made about a system when objects within the system experience rotation?</td></tr>
<tr><th colspan="2">Acquisition</th></tr>
<tr><td>Knowledge
Students will know…
• All equations assume constant values for force and angular acceleration
• When considering non-constant forces or angular accelerations, use the average force or average angular acceleration.
$\tau = r \times F$
$\Sigma\tau = I\alpha$
$x = r\theta$
$v = r\omega$
$a = r\alpha$
$\omega = \omega_0 + \alpha t$
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$L = r \times p = I\omega$
$\tau\Delta t = \Delta L$
$I \propto mR^2$
• A constant net torque around a fixed axis will cause constant angular acceleration.</td><td>Skills
Students will be able to…
• Solve problems utilizing rotational dynamics considerations
• Design an experiment to predict and investigate the outcome of any situation using torque and other angular quantities.
• Within the context of a lab whose purpose is to answer a posed question about torque and rotational motion, appropriately select and justify the process for data acquisition.
• Utilize any given rotational dynamics relationship to make predictions about the effects of changing one or more variables on other quantities within those relationships
• Utilize algebra knowledge to symbolically and numerically</td></tr>
</table>

	- Only forces perpendicular to an object's radius of rotation cause torques. - Static equilibrium within a system/object occurs when the sum of forces and the sum of torques on the system/object is zero. - Angular acceleration is the rate at which angular velocity of a given object or system changes. - All linear kinematic, force, and momentum quantities will have an angular equivalent. - The angular momentum of a system experiencing no external torques will remain constant. - When considering the net torque around an axis, the direction of the rotation a given force will cause determines the rotational motion (CCW+) - The moment of inertia is the angular analogue of mass and determines the torque needed for a specific angular acceleration. - In order for an object to roll, there must be friction to supply the torque. Without friction, the object would just slide.	manipulate and solve equations for specific variables. Justify and explain predictions and conclusions made in laboratory experiences based on the points from the understanding and knowledge components of this template.

Stage 2 – Evidence		
CODE (M or T)	**Evaluative Criteria** (for rubric)	**Performance Task(s)** ***Students will demonstrate meaning--making and transfer by…***
M		Angular Kinematics Lab
M		Torque and Angular Acceleration Lab
M		Angular Momentum Video Analysis Lab
M		Explaining and Improving Past and Present Technologies
T		Catapult/Trebuchet Project
		Other Evidence (e.g., formative)
M		Torque Quiz
M		Angular Kinematics Quiz
M		Angular Momentum Quiz

Stage 3 – Learning Plan		
CODE (A, M, T)	Pre---Assessment *How will you check students' prior knowledge, skill levels, and potential misconceptions?*	
	Learning Activities	Progress Monitoring (e.g., formative data)
A	Angular Kinematics Notes	Checks for understanding
A	Angular Kinematics HW	Monitoring/listening to students
A	Warm-Ups	Monitoring/listening to students
A	Hoop vs. Disk Demo http://www.as.wvu.edu/phys/demobook/rot_mech/rot_mech_b1.htm	
A	Torque and Angular Acceleration Notes	Checks for understanding
A	Torque and static equilibrium HW	Monitoring/listening to students
A	Angular Momentum Notes	Checks for understanding
A	Angular Momentum HW	Monitoring/listening to students

Note: The unit calendar has been written with a fairly loose, predictable structure for the purpose of allowing users to modify/adapt the plan to suit classroom needs. The scale of the project can also be modified to accommodate classroom needs by lengthening or reducing the amount of time required to complete it. Warm ups have not been provided, but should be created based on what your students seem to struggle with. It can range from big picture issues such as the difference between angular velocity and angular acceleration, to math issues like which angle theta to use in torque problems.

Unit Calendar				
1. Angular Kinematics Provide Trebuchet/Catapult project description and discuss **Notes/HW – Angular Kinematics**	2. Angular Kinematics Warm-Up Students work together on homework	3. Angular Kinematics **Lab – Angular Kinematics** Collaboration on homework persists during any lab downtime	4. Angular Kinematics Lab – continued Collaboration on homework persists during any lab downtime	5. Angular Kinematics **Clock Tech Explanation –** Students write a paragraph and then spend time in peer review.

6. Angular Kinematics **Angular Kinematics Quiz**	7. Torque/Angular Acceleration **Hoop vs. Disk demo** – students take time to write/share predictions **Notes/HW – Torque and Angular Acceleration**	8. Torque/Angular Acceleration Warm-Up Students work together on homework	9. Torque/Angular Acceleration **Lab – Torque and Angular Acceleration** Collaboration on homework persists during any lab downtime	10. Torque/Angular Acceleration Lab – continued Collaboration on homework persists during any lab downtime
11. Torque/Angular Acceleration Lab – continued Collaboration on homework persists during any lab downtime	12. Torque/Angular Acceleration **Bicycle Tech Explanation**	13. Torque/Angular Acceleration **Torque/Angular Acceleration Quiz**	14. Angular Momentum **Notes/HW – Angular Momentum**	15. Angular Momentum Warm-Up **Diving Tech Explanation** Students work together on homework
16. Angular Momentum **Lab – Angular Momentum**	17. Angular Momentum Lab – continued	18. Angular Momentum **Windmill Tech Explanation**	19. Angular Momentum **Quiz – Angular Momentum**	20. Catapult/Trebuchet Project
21. Catapult/Trebuchet Project	22. Catapult/Trebuchet Project	23. Catapult/Trebuchet Project	24. Catapult/Trebuchet Project	25. Catapult/Trebuchet Project